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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
NORTHEASTERN FOREST EXPERIMENT STATION
AMHERST, MASSACHUSETTS

INVESTIGATIVE PROGRAM.

1927.

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INVESTIGATIVE PROGRAM

1927

NORTHEASTERN FOREST EXPERIMENT STATION

ANNUAL INVESTIGATIVE PROGRAM - 1927

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NORTHEASTERN FOREST EXPERIMENT STATION

ANNUAL INVESTIGATIVE PROGRAM - 1927

General Policy

Scope and Character of Work.

There has been no important change in the scope and character of the Station's work since its establishment in the summer of 1923. These may be briefly summarized as follows:

(1) The Station is a research organization devoted to the study of the forest problems of New England and New York. Office and laboratory headquarters are maintained at Amherst, Mass., in cooperation with the Massachusetts Agricultural College, but the field work of the Station covers the entire region indicated.

(2) Its investigations are at present concerned primarily with forest protection, forest production, and forest management. Work in forest pathology and forest entomology is handled by representatives of the Bureau of Plant Industry and Bureau of Entomology who are permanently attached to the Station.

(3) No attempt is made to cover the entire field, since with the limited funds available this would mean a wasteful scattering of the Station's efforts with slow and unsatisfactory progress on any one project. In the attempt to do thoroughly the work actually undertaken, its program includes only nine major projects.

(4) The field work of the Station has so far been centered largely in the northern part of the region, where much less investigative work has been done by other agencies than in the southern part of the region.

(5) A special effort is being made to keep office work abreast of field work. Experience shows that the computation and analysis of field data requires more time than their collection, and that it is poor policy to accumulate such data beyond the point to which full use can be made of them.

(6) Field studies will gradually be concentrated, so far as practicable, at branch stations where conditions representative of different parts of the region can be found. Experience elsewhere has shown this to be much more economical and effective, particularly with permanent sample plots, than to scatter the work throughout the region.

(7) So far as suitable conditions can be found, permanent sample plots will be established only on publicly owned land or on privately owned land which is under definite contract to be left undisturbed for a stated period long enough to complete any experiments started on them. Without such a contract the danger of interference with any work started on private lands is ordinarily too great to justify their use.

(8) It is a part of the duty of the Station to make known the results of its experiments and to demonstrate the application of these on a larger scale. It cannot, however, ordinarily undertake to advise individual owners in the management of their forest lands.

(9) The Station desires to work in the closest possible cooperation with all other agencies interested in forest research, and to encourage activities in forest research by others. One of its first pieces of work was to compile and distribute, for the benefit of any who might be interested, information as to the forest investigations already under way in the Northeast.

(10) As a means of securing assistance in its own activities and of promoting cooperation, the Northeastern Forest Research council was organized during the winter of 1924 by the Secretary of Agriculture to serve in an advisory capacity to the Station and to other forest research agencies in the region. This Council has met regularly twice a year and has made helpful recommendations on many important points.

A mimeographed statement dealing with the object, scope, organization, and activities of the Station was widely distributed among interested institutions and individuals throughout the region under date of April 1, 1926.

Branch Stations.

Much information has been brought together during the past year in connection with plans for branch stations as to the forest regions, climatic conditions, geological formations, and soil conditions in the Northeast. A map showing the forest regions is attached. Maps have also been prepared showing graphically the following information concerning climatic conditions:

Temperature data.
- Normal surface temperature for the year.
- Absolute maximum temperature.
- Absolute minimum temperature.
- Average date of last killing frost in spring.
- Average date of first killing frost in fall.
- Length in days of the average frostless season.

Precipitation data.
- Average annual precipitation.
- Average spring precipitation.
- Average summer precipitation.
- Average warm season precipitation.
- Average fall precipitation.
- Average winter precipitation.
- Average annual snowfall, unmelted.
- Average annual number of days with snow cover.

Sunshine data.
- Average number of clear days.
- Average number of cloudy days.
- Average duration in hours of sunshine during the frostless season.

Relative humidity data.
- Average annual relative humidity per cent.
- Average relative humidity at 2 P.M. in January, April, July, and October.

Wind movement data.
- Average hourly wind velocity during the frostless season.

Evaporation data.
- Annual evaporation in inches.

No attempt has been made to place the geological formations or soil conditions in the region on a single small scale map, since these vary so rapidly that a generalized map of this character would be of comparatively little value. Instead, a number of large scale maps covering different parts of the region have been brought together for study in connection with local conditions. The fact that the entire region has been so thoroughly glaciated and that the surface soil consists so largely of glacial deposits makes the geological formations and bed rock of less interest than would otherwise be the case.

Among the maps so far brought together are large scale geological maps of Massachusetts, Rhode Island, and parts of New York; much smaller scale maps showing the bed rock, geological and glacial features of New Hampshire; a very detailed large scale map showing all of the glacial features in central Massachusetts; and a small scale geologic map of North America from Bowman's "Forest Physiography". The geology of Connecticut has also been pretty well covered, but it is doubtful how much can be found for Maine and Vermont. Some soil maps, particularly for southern New England, have been prepared by the Bureau of Soils, and a small scale soil map of Connecticut has recently been prepared by the Connecticut Agricultural Experiment Station.

It is obvious from a study of the available material that it will be impossible through the establishment of a reasonable number of branch stations to cover all of the forest, climatic, geological, and soil conditions in the regions. The best that can be done is to select reasonably representative areas, particularly from the standpoint of forest types, and to concentrate intensive studies at these. To make the results generally applicable, additional work of a less intensive character will have to be done in other parts of the region, and in many cases intensive studies may also be necessary from time to time to determine, for example, the exact influence of geological formations or soils not found at the branch stations.

Selection of a branch station in the White Mountain National Forest has already been made. Formal recommendation for its establishment will be submitted as soon as agreement on details has been reached with the supervisor of the White Mountain National Forest and the District Forester. This proposed branch consists of two distinct tracts about fifty miles apart but connected by an excellent automobile road. One tract is in the north central part of the Forest, contains about 3,350 acres, and includes the Gale River guard quarters. The east half is practically level and was completely burned about twenty years ago. It has since come up chiefly to aspen, with some openings. The west half runs well up on the slopes of Mt. Cleveland, was formerly heavily cut, chiefly for spruce, but has not been burned in recent years. The present growth consists chiefly of pure stands of spruce and balsam fir, mostly young but of different age classes, and of mixed stands of spruce, balsam fir, and northern hardwoods, partly even-aged, but more commonly with scattering wolf hardwoods.

The other tract comprises a natural topographic unit of about 5,100 acres immediately south of the Bartlett ranger station, and lies practically in the center of the Forest. The stand now consists almost entirely of northern hardwoods, with small amounts of spruce and balsam fir at the upper elevations. With the hardwoods occurring in all sorts of mixtures and in a wide variety of age classes, it is an ideal location for experiments with northern hardwoods, which in the long run will probably be the most important species on the Forest. There is also considerable paper birch and a little white pine on parts of the tract.

Both tracts are easily accessible by rail and automobile. Markets for fuelwood from thinnings and improvement cuttings are available at Bethelem and Bartlett. Forest conditions are as representative of the region as can be found on any two or three areas of reasonable size. The chief lack in this respect is in merchantable stands of spruce and balsam fir, of white and red pine, and of aspen, suitable for methods of cutting studies. Such stands are, however, easily accessible by automobile from the tracts selected. It is believed that on the whole they meet the requirements for a branch station as nearly as is feasible.

In addition to the White Mountain branch station, present plans contemplate the selection within the next few years of branch stations in central or northern Maine, in the Green Mountain region of central Vermont, and in the Adirondack mountains of New York. Amherst itself will serve as a center of work for all of the territory within reach of it, which includes a considerable part of the white pine and sprout hardwoods regions.

These plans contemplate the continuation of intensive work in the spruce and northern hardwoods regions, where four of the proposed branch stations will be located. Emphasis is placed on this region, because of the rather wide variation in local conditions in different parts of it, and because of the fact that so much less work is being done there by other research agencies than elsewhere in the Northeast. There should undoubtedly some time be another branch station in the Allegheny hardwoods region of southwestern New York, but plans for its establishment have been deferred until sufficient apropriations are available to permit of considerable expansion in the Station's activities. It is also possible that in addition to the work which can be handled directly from Amherst consideration should some time be given to the establishment of branch stations in the white pine and in the sprout hardwoods regions. For the present, however, it has seemed best to continue the policy of concentrating the work of the Station very largely in a single region.

Cooperation.

NORTHEASTERN FOREST RESEARCH COUNCIL. Two meetings of the Northeastern Forest Research Council have been held as usual during the past year. The field meeting on September 3 and 4, 1926, was held at the demonstration and research forest of the Yale School of Forestry near Keene, New Hampshire. The morning of September 3 was spent in a general survey of the forest, and the afternoon in a more careful inspection of the research work now being carried on by Professor Toumey and his assistants. The business meeting of the Council was held that evening. September 4 was the annual field day of the Yale Forest. Members of the Council took advantage of the opportunity to participate in the usual tour of inspection and in the informal program following lunch in the pine grove near the headquarters lodge.

The following recommendations were made to the Secretary of Agriculture as the result of action taken at this meeting:

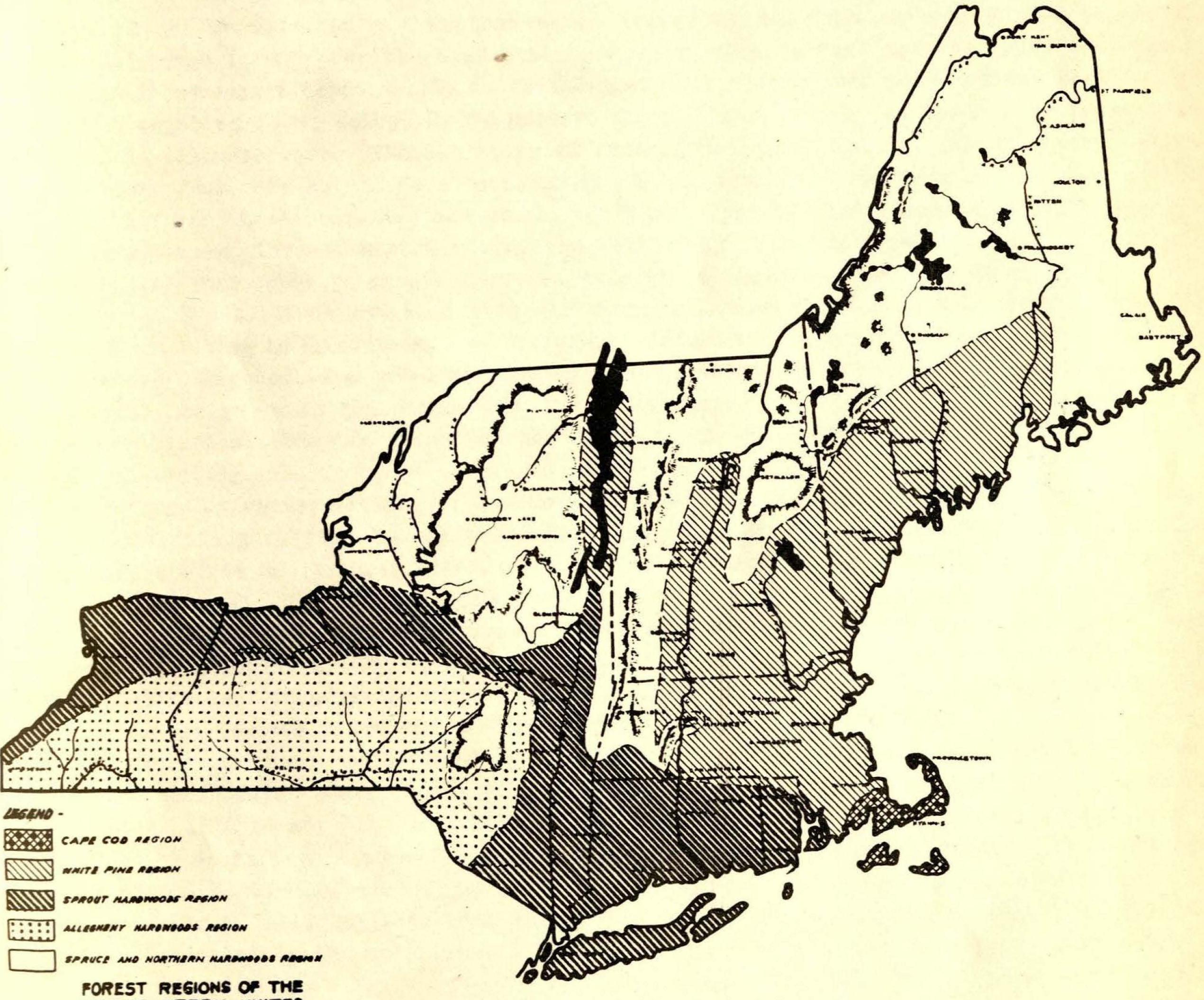
1. That steps be taken to secure the approval by Congress of a basic act which would place the forest research activities of the Department of Agriculture throughout the country on a more adequate and stable basis. Such an act should make immediately available sufficient funds for the effective operation of each of the regional Forest Experiment Stations and should provide for automatic annual increase up to a reasonable amount.

2. That the allotment for the Northeastern Forest Experiment Station be increased at the earliest possible moment to at least $50,000, which is regarded as the absolute minimum necessary for it to operate effectively on anything like a reasonable basis.

3. That the Bureau of Entomology allotment for forest insect investigations in the Northeast be increased for the next fiscal year by $5,000 to make possible the continuation of the white pine weevil study now supported chiefly by contributions from private timberland owners, and to permit undertaking studies of other important forest insects in the region, notably the bronze birch borer.

4. That an effort be made to extend the influence and increase the effectiveness of the Northeastern Forest Experiment Station by securing the active cooperation of state forestry departments, agricultural experiment stations, and forest schools in the joint study of forest problems of regional interest.

5. That a specialist in forest soils be attached to the Northeastern Forest Experiment Station at the earliest possible moment.


FORT KENT
VAN BUREN
FT FAIRFIELD
ASHLAND
HOULTON
PATTEN
CALAIS
EASTPORT
PROVINCETOWN
LEGEND -
▩ CAPE COD REGION
▨ WHITE PINE REGION
▧ SPROUT HARDWOODS REGION
⁘ ALLEGHENY HARDWOODS REGION
☐ SPRUCE AND NORTHERN HARDWOODS REGION

FOREST REGIONS OF THE
NORTHEASTERN UNITED
STATES

Northeastern Forest Experiment Station
P.W. Stickel Jan 27

6. That in any re-districting which may be considered in connection with the establishment of the forest experiment station for the Middle Atlantic States, the entire state of New York be retained in the territory covered by the Northeastern Station.

The Secretary replied that he was in full sympathy with the various recommendations made by the Council but that the proposed expansion of the activities of the Northeastern Forest Experiment Station must depend largely upon the financial situation. In connection with the proposal to place the forest research activities of the Department throughout the country on a more adequate and stable basis, he stated that he would like to defer any decision as to the specific means suggested to accomplish this end until he could consider the matter in connection with a report on forest research then in process of publication by the Society of American Foresters which he understood contained recommendations along somewhat the same line. He also stated that so far as he could foresee there is no reason why the entire state of New York should not be retained within the region served by the Northeastern Forest Experiment Station, although it was possible that other stations, such as that for the Allegheny region, might find it necessary occasionally to extend their activities into parts of New York.

The terms of F. H. Colby, R. S. Hosmer, C. H. Keith, and J. C. Kendall expired at the close of the calendar year. The Secretary of Agriculture asked Messrs. Hosmer and Kendall to serve another four-year term. He also asked Mr. E. H. Thomson, president of the Federal Land Bank, Springfield, Massachusetts, and Mr. B. S. Viles, forester and timberland owner, Augusta, Maine, to serve in place of Messrs. Colby and Keith. Mr. Thomson accepted, but Mr. Viles expressed regret that pressure of other duties made it impossible for him to do so.

Mr. H. G. Philbrook resigned from the Council in the fall of 1926 because of the fact that he is now living in Florida and is, therefore, not in a position to attend future meetings. The Secretary of Agriculture asked Mr. Dudley Harmon, executive vice-president of the New England Council, to serve in his place, but the latter expressed regrets at being unable to accept the invitation. The two vacancies now existing in the Council will be filled before its next annual meeting.

The regular winter meeting of the Council was held in the building of the Hampden County Improvement League, West Springfield, Massachusetts, on February 3, 1927. The fact that the meeting was one of the best attended so far held indicates the interest taken by the members of the Council in its activities, and their desire to assist in every way possible in promoting the sound and orderly development of forest research in the region. Several guests were present, including Mr. E. N. Munns, chief of the Office of Forest Experiment Stations in the Forest Service. This is the first time that the Washington office has been represented at a meeting of the Council since its initial meeting in the winter of 1924.

The more important action taken, at the meeting may be summarized as follows:

1 The Council re-affirmed its recommendation of the previous summer as to the desirability of an organic act placing forest research activities of the Department of Agriculture throughout the country on a more adequate and stable basis; expressed general approval of legislation along the lines followed in the bill (H.R. 17406) introduced by Mr. McSweeney in the closing days of the last Congress; and voiced the hope that legislation of this sort would be vigorously supported by the Department of Agriculture and acted upon favorably by Congress in the near future.

2. Arrangements were made for the preparation of a list of a few important projects which are in urgent need of investigation but which cannot now be undertaken in an adequate way by the Northeastern Forest Experiment Station for lack of funds, with the hope of securing cooperation from other agencies in their conduct. The establishment of permanent sample plots was particularly emphasized as a project that is admirably adapted to being handled by cooperative effort on the part of a considerable number of agencies on a regional basis.

3. The Northeastern Forest Experiment Station was requested to compile and issue a

list of all the permanent sample plots which have so far been established in the region. Such a list will be of considerable interest and value to all of those interested in forest research and will undoubtedly help to stimulate further activity in this field. Mimeographed instructions for the establishment of sample plots in connection with studies of methods of cutting were rather generally distributed by the Station last year.

4. The importance of assisting timberland owners to market profitably their forest products was stressed as one of the best means of interesting such owners both in improved methods of forest management and in the research necessary for the development of such methods. Lists of the wood-using industries in each state, with information as to their requirements are of great value in enabling owners to find profitable markets for their forest products, and the attention of the state foresters in the Northeast is being called to the desirability of preparing and maintaining up-to-date lists of this sort.

5. Progress made by the Northeastern Forest Experiment Station during the past year on its major projects was considered in some detail, as were also its plans for the coming season. These were approved by the Council, with the recommendation that the work already under way be continued as planned, and that no new projects be undertaken at this time. The importance of the early publication of the results already obtained by the Station was emphasized.

It is probable that for its next field meeting during the coming summer the Council will accept the invitation of the New York State College of Forestry to meet at its camp at Cranberry Lake in the western Adirondacks. These field meetings are proving of great value in giving the members of the Council comprehensive and first-hand information as to forest conditions and forest research under way in different parts of the region.

The Northeastern Forest Research Council now has a recognized and important place in the forest research activities of the region. Its recommendations are listened to with respect and are proving helpful both in stimulating forest research and in bringing about better coordination of effort.

MASSACHUSETTS AGRICULTURAL COLLEGE. Cooperation with the Massachusetts Agricultural College, at which the headquarters of the Station are located, has continued to be entirely satisfactory. Contacts previously established have been maintined and new contacts made. Relations with workers in allied fields at the College have been friendly and helpful in every respect.

The only change in quarters during the past year has resulted in placing another small room at Dr. Spaulding's disposal. The Station now occupies two large rooms on the first and second floors in the south end of French Hall and two small rooms in the third story of Clark Hall. During the winter the quarters in French Hall are rather badly crowded, and additional space will be needed as soon as any enlargement of the staff becomes possible. Present indications as to appropriations do not indicate, however, that this is likely to become a serious problem in the near future.

No instruction has been given to students of the College since the winter of 1926, when a series of 20 lectures on forest ecology was given by Mr. Westveld and Mr. Stickel to a class of three graduate and nine undergraduate students. While this course was apparently highly satisfactory, it has not been repeated during the present winter because of the lack of a sufficient number of students particularly interested in this field to make it worth while.

Plans have been made by the Division of Horticulture at the College for offering a number of special courses to advanced students and others, both from the College itself and from other parts of the country, during the summer of 1927. It desires to include instruction in forest ecology among the courses to be offered. If these plans are carried out, some member of the Station staff, very likely Mr. Stickel, will probably assist for approximately three weeks in giving the course. It is believed that arrangements to do this can be made without interfering materially with the regular work of the Station, and that a special effort should be made to cooperate with the college in this way.

OTHER AGENCIES. Reference has already been made in connection with the discussion of specific projects to cooperation with various other agencies. Acknowledgment should, however, be made here of the following contributions which have been received during the past year in connection with the Station's forest fire projects:

State of New Hampshire	$60
State of Vermont	500
Harvard Forest	1,000
Empire State Forest Products Association	260

Cooperation has also been received from the states of Maine and New Hampshire in the coding of the forest fire records for those states. The New York State College of Forestry has maintained the fire weather station established at the Pack Demonstration Forest at Cranberry Lake in 1925, and has made the records therefrom available for the use of the Station. Finch, Pruyn and Company have cooperated in furnishing quarters and subsistence for the man in charge of the fire weather station at Elk Lake, New York. Equipment for the fire weather study has been loaned by the Harvard Forest and Clark University.

Arrangements have already been completed for continued cooperation through the Harvard Forest in the fire weather study at Petersham to the extent of $1,000. The Forest Commissioner of Maine has agreed to contribute not to exceed $2,000 for the establishment of a similar station in north central Maine, at which inflammability studies will also be made. To what extent cooperation may be received from other sources is not yet known.

Cooperation has been continued with the state of Maine in the studies of the spruce budworm and other forest insects being handled by Mr. Peirson, who has, as in previous years, spent some time at the Station. Mention should also be made at this point of the cooperation of the Connecticut Agricultural Experiment Station, the Vermont State Department of Agriculture, and the New Hampshire Agricultural Experiment Station in the white pine weevil project. Conduct of this project on its present scale has been made possible only by contributions of $2,500 a year from interested timberland owners during the years 1925 and 1926.

There have been no developments in connection with the Advisory Committee from the Pulp and Paper Industry to the Department of Agriculture, which was appointed in the winter of 1925. The Station has, however, maintained fairly close relations with the Woodlands Section of the American Paper and Pulp Association, and participated actively in the program of its annual meeting in February, 1927.

A special effort has been made to maintain more or less close contacts with other organizations and individuals in the region who are interested in forest research or its application. Numerous talks have been given during the year to a wide variety of organizations.

Record should be made of the continued effective cooperation with the Bureaus of Plant Industry and Entomology through the permanent assignment of a forest pathologist and a forest entomologist to the Station. The close connection of these men with the rest of the staff is proving more and more valuable as time goes on. The assignment to the region of a representative of the Weather Bureau to devote his entire time to the meteorological aspects of fire weather predictions will also be of great value. It is hoped that the fact that his headquarters will be in Boston will not interfere with having his work conducted in the closest possible cooperation with the Station.

Major Projects - Progress and Plans

Methods of Cutting in Spruce and Balsam Fir Stands (Mc-1, M. Westveld).

The main objects of this study are to determine (a) the best methods of cutting to use to obtain satisfactory natural reproduction under various conditions in the shortest possible time, and (b) the rate of growth of seedlings and larger trees left after cutting. Altogether some 420 temporary sample plots have so far been established in the spruce flat, spruce and hardwoods, and spruce slope types in Maine, New Hampshire, Vermont, and New York. Four permanent sample plots were established in 1924 at Cherry Mountain on the White Mountain National Forest.

Field work during the past year involved chiefly intensive studies of the permanent sample plots on the White Mountain Forest, and of older sample plots established by the Forest Service in the early days of its sample plot work. A few additional temporary sample plots were also taken to fill out certain weak spots in the available data. Continuous records of radiation in stands of different density in the White Mountain sample plots were obtained for approximately two weeks toward the end of the summer. Several measurements of ultraviolet light in the same stands were also made.

Through the cooperation of the Connecticut Agricultural Experiment Station, Mr. M. F. Morgan of that station and Dr. G. W. Conrey of the Ohio Agricultural Experiment Station spent several days on the plots in company with Mr. Westveld and Mr. Gast, studying soil conditions. Their study disclosed the fact that slight changes in topography and drainage result in rapid changes in soil types in comparatively small areas. Five distinct soil types were found in the four sample plots studied, the differences between these resulting chiefly from differences in drainage as affected by glacial formation. Several typical soil profiles were studied and nitrogen determinations from these have been made.

A comprehensive report on the silvicultural results of this study to date has been prepared for publication during the coming year. Some of the more striking facts brought out in it are as follows:

Cut-over lands in the spruce flat, spruce and hardwood, and spruce slope types are as a rule well stocked with advance spruce and balsam fir reproduction. There is, however, a pronounced lack of spruce and balsam fir seedlings coming in subsequent to cutting. Where advance reproduction is present, therefore, almost any method of cutting will result in at least a fair amount of spruce and balsam fir seedlings in the new stand. Where advance reproduction is not present, heavy cutting, which is now the prevailing practice in pulpwood cuttings, is almost certain to result in the virtual abandonment of the area to hardwoods. In general, the number of spruce and balsam fir seedlings is roughly proportional to the volume of spruce and balsam fir in the original stand, and inversely proportional to the basal area of the hardwoods. It is not unusual, however, to find considerable numbers of pulpwood seedlings even in stands having a high per cent of hardwoods. The latter, particularly in the spruce and hardwoods type, reproduce vigorously after cutting, and often interfere seriously with the development of the softwoods.

Cut-over areas in the spruce flat type ordinarily maintain their original representation of conifers, but with a strong tendency for the amount of balsam fir to increase considerably at the expense of the spruce. On cut-over areas in the spruce and hardwoods type, on the other hand, hardwoods, because of their more abundant reproduction and more vigorous early growth following cutting, are to a large extent supplanting both spruce and balsam fir. Where yellow birch is the predominating hardwood in mixture, advance reproduction of the softwoods will usually hold its own if it averages two feet or more in height at the time of cutting; while where beech and hard maple are prominent in the mixture an average height of four feet is necessary for the softwoods to hold their own. Some relief from hardwood competition by either girdling or cleaning will greatly promote the development of the softwood reproduction in either case, and is practically essential when the spruce and balsam fir are of smaller sizes than those indicated. Further information is much needed as to the details and costs of both methods.

Suppressed spruce and balsam fir reproduction responds vigorously in height growth following the removal of the overhead canopy through cutting. The capacity of suppressed seedlings to recover promptly after cutting varies both with the degree of suppression and with their height at time of release. For example, four-foot red spruce seedlings put on a net growth of 11½ feet in 12 years, as against a net growth of only 5½ feet in the same period by 10-foot suppressed saplings.

In general the best response is from seedlings which are between two and five feet in height at the time of cutting. Spruce seedlings of all sizes on cut-over areas where the overhead canopy has been entirely removed average nearly six feet of height growth in 12 years, as against 20 inches in the same time under a dense canopy. Balsam fir seedlings respond more quickly and grow more rapidly after liberation than red spruce. Thus, 36 balsam fir and 57 red spruce seedlings of practically equal height at the time of release put on a height growth in a period of 11 years of 88 and 68 inches respectively.

Considerable advance reproduction of both softwoods and hardwoods is usually destroyed during logging operations. Available figures indicate that an average of about 25 per cent of the reproduction of all species and size classes is destroyed in the process of logging, with the heaviest loss in the three to five-foot seedlings. Since it is these which make the most rapid growth and form the main reliance for the next crop of pulpwood, special pains should be taken to reduce this damage.

Seedbed conditions play an important part in the establishment of spruce and balsam fir reproduction, particularly after cutting. In old growth stands, where there is usually ample moisture in the surface soil and where competition from brush is not important, all types of seedbeds, regardless of actual soil characteristics, appear suitable for spruce and balsam fir reproduction. After cutting, however, old logs and dense litter dry out rapidly, with the result that spruce and balsam fir germination is more profuse on exposed mineral soils from which the litter and plant growth have been removed. A fall tally following spring germination on a seedbed from which all litter, branches, moss, and herbaceous vegetation had been removed showed an average of 4,700 spruce and 22,500 balsam fir seedlings per acre, as against 1,700 spruce and 4,700 balsam fir on plots which had been left undisturbed. Hardwoods were much more abundant on both plots, and particularly on the exposed ones, where the number of yellow birch ran as high as 370,000 to the acre. These facts probably indicate in part at least the reason for the lack of spruce and balsam fir reproduction following cutting, and for the relatively greater reproduction of hardwoods.

So far as cutting methods are concerned, pure stands of spruce and balsam fir containing adequate advance reproduction should be cut clean. Where advance reproduction is lacking, from a third to a half of the trees should be removed in the first cutting, and the remainder after reproduction has become well established. An even lighter first cutting may be necessary to avoid heavy losses from windfall in stands with exceptionally tall trees, on areas especially exposed to the wind, or on sites with unusually shallow or moist soil.

Clear-cutting will also maintain a satisfactory proportion of softwoods in the mixed spruce and hardwoods type, if the advance reproduction has attained an average height of two feet in the yellow birch sub-type or of four feet in the hard maple sub-type. The softwood reproduction can be greatly favored and growth and yield increased by judicious girdling of the old growth hardwoods or by cleaning the young competing hardwoods. Carefully regulated grazing will also help to hold back the latter.

When softwood reproduction in the spruce and hardwoods type is inadequate, it will be difficult to obtain any considerable amount of softwoods at reasonable expense under any method of cutting. Such stands can most advantageously be managed to favor the best hardwoods. Conditions vary so widely that it is impossible to lay down any hard and fast rules of general application, and each tract must be considered in the light of local conditions.

Plans for the coming year contemplate continued intensive study of the White Mountain sample plots and of some 20-year old permanent sample plots at Waterville, New Hampshire. In connection with the remeasurement of the intensive reproduction quadrats on the White Mountain sample plots, more detailed studies of soil types tha were possible last year will be made by Mr. Morgan in order to obtain more definite information as to the influence of soil conditions on the establishment and development of reproduction. Additional quadrats will also be established to determine the effect of a wide variety of seed bed conditions on the germination and establishment of reproduction of different species.

A trip will probably be made to Newfoundland to study carefully the results obtained from a series of permanent sample plots covering some 144 acres which were established in 1920 to determine the effect of different methods of cutting in pulpwood stands. These plots are now old enough to yield much data of great value in connection with this project. If time permits, some permanent sample plots will be established at Cherry Mountain on the White Mountain on the White Mountain National Forest to determine the effect of hardwood cleanings on the development of spruce and balsam fir reproduction; and a few temporary plots will be established on pulpwood areas which have been cut by other methods than clear cutting.

In addition to the silvicultural phase of the study, many figures have been obtained on the rate of growth and probable yield both of the residual stand and reproduction on variously stocked areas in different forest types. These figures are now being worked up, and a report on this phase of the study will be prepared during the coming year. While accurate predictions of yield will be difficult, if not impossible, under the very wide variety of conditions found on cut-over areas, it is believed that useful examples of the results on specific areas can be given and that tables can be prepared indicating at least approximately the yield to be expected at different ages following cutting under specified conditions.

Slash Disposal (Mb-1, P. Spaulding, M. Westveld, and H. J. MacAloney).

This project aims to determine (a) the relation of slash of various species to the protection of the forest from fire, disease, and insects, and (b) the relative desirability of various methods of slash disposal. Field work, started in 1925, has so far been conducted chiefly in the white pine and in the spruce and northern hardwoods types.

A report on the decay of white pine slash in southern New England will be submitted shortly for publication. The field work on which this report is based has centered around Petersham, Massachusetts, but has also covered considerable areas in north central Massachusetts and in south central New Hampshire. The study shows that the usual progress of decay in white pine is about as follows:

1st year--Drying of the needles and branches and intensive work of insects under the bark on the lower side of the slash.

2nd year--The bark loosens where the insects have worked, and saprot by LENZITES SEPIARIA and POLYSTICTUS ABIETINUS begins. These two fungi fruit sparingly.

3rd year--The leaves mostly fall and form a mat midway down in the piles. The bark is mostly loose and falling.

4th year--The bark practically all falls off. Saprot is well under way. The top slash is dry and brittle. Fruiting bodies form on the bottom slash.

5th year--The top slash is weakened by numerous pockets of rot made by LENZITES SEPIARA, and the upper branches begin to break at these pockets. Sapwood of the larger pieces is well rotted by POLYSTICTUS ABIETINUS. In the lower slash, fruits of a number of the less common wood rotting fungi appear.

6th year--LENZITES SEPIARIA attacks the heart wood of the upper branches and their breaking at pockets of rotted wood increases.

7th year--The piles begin to flatten by the breaking of the upper branches into pieces one to two feet long.

8th year--The twigs begin to fall from the branches.

9th to 10th years--The slash piles are well flattened and branches fall from the trunks.

11th to 15th years--Most of the slash is well rotted, but pieces of the smaller branches persist almost sound and dry.

16th to 20th years--Most of the slash disintegrates and forms a layer of mold. Some pieces of small branches persist, practically sound, for an almost indefinite period.

Although about 25 different fungi are known to rot slash of white pine, two of these are responsible for most of the work. LENZITES SEPIARIA, which works only in well-exposed slash, is especially important because it is about the first to attack the sapwood. Later it also attacks the heart wood and altogether probably rots more slash than any other fungus. POLYSTICTUS ABIETINUS attacks the thicker sapwood but does not continue into the heart wood. It occurs chiefly toward the middle of slash piles and works in moister situations than can LENZITES SEPIARIA. The other fungi work largely toward the bottom of the piles, either near the ground or in contact with it.

The nature of the slash itself has much to do with the rate of decay. Slash from rapid growing trees with considerable sapwood rots much faster than that from older, slower growing trees with a larger proportion of heart wood. Small branches resist decay longest, probably because they dry out so promptly and season so thoroughly that fungi have little chance to attack them. The conditions studied were not sufficintly varied to make it possible to draw definite conclusions as to the influence of sites and soils on the rate of decay. It is, however, clear that dry, sterile sand greatly retards decay because of the extreme dryness and **heat in such situations, and that partial shade where the soil is not distinctly wet favors** rapid decay. On soils which are wet most of the time, the slash becomes water-logged and persists for extremely long periods.

Under favorable conditions, white pine slash will disintegrate but not entirely disappear in about 15 years. Five to ten years more are required for the rotted wood to disappear, and even then a layer of flattened, fibrous wood mold is hidden by the recent debris of the forest. Conditions adverse to decay may delay disintegration of the slash for ten years or longer. It is, therefore, important to avoid these so far as possible.

On moderately moist, well-drained soils, the optimum condition for decay is under the partial shade resulting from partial cutting. In such situations, the slash rots most quickly if it is lopped and scattered or loosely piled so as to bring a maximum amount into direct contact with the ground. On dry, sandy soils, unlopped, loosely piled or scattered slash dries excessively and rots very slowly. Here slash piled closely, or lopped and piled so as to lie compactly together with a minimum surface presented to the sun, will rot most quickly. On soils which are moist the year round, slash lying directly on the ground becomes water-logged, so that fungi cannot attack it. Scattered or lopped slash, therefore, remains unrotted for an excessively long time. Here high piles, preferably placed on old logs, rocks, or anything to hold the bottom layers off the ground, will promote decay.

From the standpoint of fire control, it is clear that complete burning of the slash provides the most effective protection. This is true both because of the comparatively slow rate of decay and the sound condition of the smaller twigs. Since these, aside from the leaves, are the most readily inflammable part of the slash, their persistence in a thoroughly dry condition means that considerable inflammable material is usually present for at least twenty years with unburned slash. The normal course of decay, is therefore, more effective in reducing the total amount of fuel than in decreasing the actual inflammability of the slash.

From the standpoint of sanitation, there is no doubt that burning of the slash is the most effective measure that can be readily undertaken. It removes a large amount of material which serves to feed a host of wood-destroying fungi, some of which may ultimately prove to be dangerous to living trees. Comparatively little is yet known as to the extent of the danger from this source, but two fungi - TRAMETES PINI and STEREUM SANGUINOLENTUM - are generally present in all coniferous forests, and are known to cause heavy damage there. The first is a definite danger to white pine, and undoubtedly occurs in white pine slash, although it has not yet been found there in the course of the present study. The latter is not definitely known to attack this species, but neither fungus should be overlooked when a choice is being made between burning slash and leaving it to rot.

The only field work on white pine slash disposal planned for the coming year involves the continuation of experiments with caged slash to determine the role played by different insects in promoting decay, and the study of temperature and humidity in the upper and lower parts of. slash piles. In addition to the Department bulletin already mentioned, the main conclusions reached as a result of the study will probably be included in a Harvard Forest bulletin now in preparation on the relation of white pine slash to reproduction. Additional work on certain phases of white pine slash disposal may prove advisable later, but is not contemplated at this time.

The study of slash decay and disposal in the spruce and northern hardwoods type has been carried on in Maine New Hampshire, Vermont, and New York. Observations of slash in both old and recent cuttings have been made in many parts of these four states. In addition, two permanent sample plots were established on the Cherry Mountain timber sale on the White Mountain National Forest in 1925 to determine the rate and character of decay in lopped and unlopped slash of maple, yellow birch, beech, spruce, and balsam fir. Three additional plots of approximately 3½ acres each were established in the same locality in 1926. On one of these, no attempt was made to dispose of the slash as left after an ordinary logging operation; on the second, both softwood and hardwood slash were lopped; and on the third the softwood slash was burned with no disposal of the hardwood slash.

From the observations so far made, which are not extensive enough to be regarded as conclusive, it appears that hardwood slash, irrespective of the method of disposal, increases the fire hazard for three or four years, and almost completely disappears in seven or eight years. Softwood slash, on the other hand, constitutes an abnormal fire hazard for at least eight to twelve years, and does not disappear in less than twenty years. As in the case of white pine, the larger softwood material rots first, and branches and twigs less than one inch in diameter remain sound, dry, and inflammable for at least ten or twelve years, and often considerably longer.

Piling and burning is undoubtedly the most effective means of disposing of softwood slash from the standpoint of protection from fire. When burning is impracticable, lopping and scattering of the slash will hasten its decay and permit the development of many seedlings which would be crushed under dense piles or windrows. Burning is hardly necessary with hardwood slash, and lopping does not appear to promote materially its decay. Conditions are so complex as to make it unsafe to draw conclusions except on the basis of a large number of observations. It is hoped that by the end of another year sufficient data will be available to justify at least a preliminary report.

In addition to the decay phase of the study, attention is being given to the effect of various methods of slash disposal with spruce, balsam fir, and northern hardwoods on the development of new and advance reproduction. Observations for this purpose have been made on the temporary sample plots established in connection with the study of methods of cutting in pulpwood stands, and are also being maintained currently on all of the Cherry Mountain permament sample plots on the White Mountain National Forest.

The amount and density of slash, and consequently its effect on reproduction, varies greatly with the amount and species of timber removed. Heavy cutting usually results in covering from one-third to two-fifths of the area with slash. Of this, nearly 50 per cent may be classified as dense, a little over 30 per cent as medium, and about 20 per cent as light. For equal volumes of timber cut, softwood slash covers only about 60 per cent as much area as hardwood slash. It averages considerably denser, however, and has a greater tendency to compact itself. On the Cherry Mountain sample plots, for example, 62 per cent of the softwood slash was classified as dense as against 32 per cent for the hardwood slash.

Unlopped hardwood tops interfere very little with the normal development of reproduction. Lopping increases somewhat, but usually not seriously, the changes of smothering the smaller seedlings.

Dense softwood slash, on the other hand, not only crushes and kills the advance reproduction beneath it, but effectually prevents the establishment of new reproduction on areas occupied by it for a period of from 15 to 20 years. Such slash should, therefore, be piled and burned from the standpoint of silviculture as well as of fire control. If burning is not practicable, lopping and scattering so as to do away with dense piles or windrows offers the next best means of preventing undue interference with the development of reproduction.

During the coming year both the mycological and silvicultural phases of the project will be continued along the lines already started. General observations of cut-over areas of different ages will be made in various parts of the region to substantiate and round out the data already obtained. Careful study will probably be made of a series of permanent sample plots established in Newfoundland in 1920, where various methods of slash disposal were tried out with many of the same species under consideration in the Northeast.

Maps will be prepared for each of the Cherry Mountain sample plots showing the location of skid roads and trails, stumps, residual tress, and slash piles, and the character of the slash with respect to its height, density, and species of which composed. Reproduction counts and observations of slash deterioration will also be made on these plots. Additional permanent sample plots may be established on the White Mountain Forest in case opportunities for covering other conditions of slope, exposure, and site are offered by current timber sales.

Growth and Yield of Spruce and Balsam Fir (ME-2, W. H. Meyer and C. E. Behre).

This project has so far been limited to the preparation of normal yield tables for even-aged, second growth stands of red spruce, white spruce, and balsam fir. Field work has included the measurement of some 400 temporary sample plots in various parts of Maine, New Hampshire, Vermont, and New York. There are believed to be representative of all the fully stocked stands of spruce and balsam fir of the desired character to be found in the Northeast. Such stands are most common on old pasture lands, although they occasionally come in after cutting, fire, or windfall.

A manuscript entitled "Yields of Second Growth Spruce and Balsam Fir in the Northeast" was submitted for publication in the spring of 1926. It has since been in the hands of the

Board of Review, from which it has just returned. Revision of the manuscript in the light of comments by the Board will be made by Mr. Meyer in the near future.

Yields of red spruce are shown in the report to be as follows:

Total Stand, Including Stump and Top.

Total Age Years	Yield per Acre in Cubic Feet of Peeled Wood Site Index 40	 Site Index 50	 Site Index 60
45	1,950	2,680	3,380
55	3,100	4,260	5,360
65	3,820	5,250	6,600
75	4,260	5,860	7,360
85	4,530	6,230	7,820

"Site index" indicates the height of the average dominant and codominant tree in the stand at 65 years of age. The most common site index for red spruce is 50, with extreme values occasionally running as low as 30 and as high as 70. On the old system of site classification Site Index 60 would correspond roughly with Quality 1, Site Index 50 with Quality 2, an Site Index 40 with Quality 3.

"Total age", as used in these tables, was determined by getting the age at breast height and adding 15 years to allow for the period necessary to reach this height. While this period should theoretically not be the same for all sites, a number of field measurements of dominant seedlings failed to show any consistent difference in this respect. It is evident that the influence on seedling development of the broad site classes ordinarily recognized in the preparation of yield tables is somewhat obscured by local variations in soil conditions and in competing vegetation which may be of minor importance to older trees but are of major importance to the young seedlings. In applying the tables it is important to determine the total age of the stand in question by finding its breast high age and adding 15 years in order that the field determination of age may be on the same basis as that used in the tables.

The volumes shown are "normal volumes", and give the total volume of the tree inside bark, exclusive of butt swell. They are taken from volume tables prepared by the form class system as developed by Mr. Behre. Careful checks showed that the average deviation of the volumes given by these tables from the scaled volumes is well within the limit of error recognized as satisfactory.

Trees 4 Inches D.B.H. and up, from a
1 Foot Stump to a 3 Inch Top Inside Bark.

Total Age Years	Yield per Acre in Cords of Peeled Wood Site Index 40	 Site Index 50	 Site Index 60
45	11.5	21.1	28.4
55	24.2	37.9	50.6
65	33.2	50.5	65.2
75	39.6	58.0	73.6
85	43.1	62.3	79.0

These volumes were first determined in cubic feet by the form class volume tables already referred to, and were then converted to cords on the basis of 95 cubic feet of solid wood to a stacked cord of 128 cubic feet. The total volume of single trees with bark averages about 12 per cent higher than the peeled volume. Since unpeeled bolts fit less closely than peeled bolts, however, an overrun of at least 15 per cent should probably be allowed in determining the solid cubic contents of stacked cords of unpeeled wood. Actual piling tests will be necessary to determine how the converting factor should be modified for material from stands of different average size.

Trees 7 Inches D.B.H. and up, from a

1 Foot Stump to a 5 Inch Top Inside Bark.

Total Age Years	Yield per Acre in Board Feet. Site Index 40	Site Index 50	Site Index 60
45	1,360	3,110	4,880
55	4,200	9,650	15,100
65	7,450	17,050	26,700
75	10,000	22,900	35,800
85	11,500	26,300	41,200
95	12,300	28,200	44,100
105	12,890	29,400	45,900

The board foot volume tables were prepared by the form class system on the basis of 16.3 foot logs scaled by the International Rule with 1/8 inch saw kerf and with no allowance for cull. Size class 30 produces few, if any, trees large enough for saw logs.

Figures for mean annual increment corresponding to these yield tables are as follows:

Total Stand, Including Stump and Top

Total Age Years	Mean Annual Increment per Acre in Cubic Feet of Peeled Wood Site Index 40	Site Index 50	Site Index 60
45	43	60	75
55	56	78	98
65	59	81	102
75	57	78	98
85	53	73	92

Trees 4 Inches D.B.H. and up, from a
1 Foot Stump to a 3 Inch Top Inside Bark.

Total Age Years	Mean Annual Increment per Acre in Cords of Peeled Wood Site Index 40	Site Index 50	Site Index 60
45	0.25	0.47	0.63
55	0.44	0.68	0.93
65	0.52	0.78	1.00
75	0.53	0.78	0.98
85	0.51	0.74	0.93

Trees 7 Inches D.B.H. and up, from a
1 Foot Stump to a 5 Inch Top Inside Bark.

Total Age Years	Mean Annual Increment per Acre in Board Feet Site Index 40	Site Index 50	Site Index 60
45	30	70	110
55	80	180	270
65	110	260	410
75	130	310	480
85	140	310	480
95	130	300	460
105	120	280	440

For Site Index 50, which may be taken as the average, the mean annual increment in total cubic feet reaches a maximum at 65 years of age; in cubic feet (or cords) of pulpwood material at 69 years; and in board feet of sawlog material at 82 years. To produce the greatest amount of high quality lumber would undoubtedly require considerably longer, since natural pruning does not take place at an early age.

The periodic annual increment, by ten-year periods, reaches the following maxima at the ages indicated:

Total Age Years	Periodic Annual Increment per Acre in Cubic Feet for Total Stand Site Index 40	Site Index 50	Site Index 60	Site Index 70
50	115	158	198	239

Periodic Annual Increment per Acre in Cords of Pulpwood Material

Total Age Years	Site Index 40	Site Index 50	Site Index 60	Site Index 70
50	1.26	1.72	2.23	2.76

Periodic Annual Increment per Acre in Board Feet of Saw Log Material

Total Age Years	Site Index 40	Site Index 50	Site Index 60	Site Index 70
60	325	740	1,160	1,580

Figures for site class 70 are included to indicate the possibilities of the species on the very best sites.

Mixed stands consisting of red spruce but with small amounts of white spruce and balsam fir have practically the same yields as pure stands of red spruce. Both white spruce and balsam fir grow faster in height when young than does red spruce. They are, however, unable to maintain so complete a crown canopy, and balsam fir stands especially seem to break up after the early ages are passed, particularly on the poorer sites. For these reasons pure stands of white spruce and balsam fir show larger cubic foot and board foot yields up to approximately 60 years of age, when they are surpassed by red spruce. Balsam fir shows a similar tendency to exceed white spruce up to about the same age, when the latter takes the lead.

The mean annual increment of nearly four-fifths of a cord of peeled pulpwood per acre up to 65 years on average sites (site class 50) and of just a cord on the better sites (site class 60) indicates that under favorable conditions the possible yields from red spruce are much higher than has been generally believed. They are particularly striking in view of the extremely slow seedling development, - 15 years to breast height. The yields shown are not, of course, found over any considerable area under natural conditions; but neither do they indicate the results that might be obtained under intensive management with one or more thinnings.

Yields of sawlog material, which at 65 years of age on average sites amount to only 17,050 board feet, with a mean annual increment of 260 board feet, are much less satisfactory than of pulpwood material. The difference is due to the high density of stocking maintained by red spruce stands with the correspondingly small average diameter. These facts are clearly brought out in the following table:

Number of Trees per Acre and Average Diameter of Red Spruce Stands at 65 Years of Age on Site Class 50.

	Number of Trees	Average Diameter
Total Stand	980	6.5
Trees 4 inches D.B.H. and up	897	6.7
Trees 7 inches D.B.H. and up	390	8.2

Understocked stands approach a more fully stocked condition with advance in age. In such stands the proportion of both cubic foot and board foot volume to the volume of normally stocked stands is much greater than the proportion of the actual number of trees to the normal number of trees. This is particularly true of board foot volume, which reaches a maximum in stands with a stocking about 65 per cent of the normal. There is little doubt that rotations could be shortened and yields increased by judicious thinnings.

In addition to revising the manuscript, work on this project during the coming year will include some piling tests to determine the solid contents of stacked cords composed of material from second growth stands of different average size. If time permits, a number of permanent sample plots will also be established in young stands of second growth spruce of various degrees of stocking for the study of mortality, approach to normality, change in form, and rate of growth in diameter, height, and volume. Further work on the application of normal yield tables to abnormal stands, and on the determination of yield in uneven-aged stands, will have to be deferred until additional funds are available.

Universal Taper and Volume Tables (ME-1, C. E. Behre).

This project involves a fundamental study of tree form. Its main object is to determine the conformity of various species to a form equation which can be used for the construction of standard taper curves, and the application of such curves in forest mensuration. A report now in process of publication brings out the great similarity in form of many commercial conifers in the United States and Europe, and develops a mathematical formula to approximate the generalized taper curve. Particular attention is devoted to the evaluation of errors arising from various sources, the analysis of which is made possible by the form class percentile taper method.

Field work during 1926 was directed chiefly toward a rounding out of the material for white spruce. The number of tree records for different species now available is as follows:

	Red Spruce	White Spruce	Balsam	All Species
Even Aged	664	601	347	1612
Old Growth	345	-	232	577
Total	1009	601	579	2189

All of the field data have been put through the necessary preliminary calculations, and the results have been transferred to punch cards and put through the tabulating machine. The material is, therefore, now ready for final analysis. Some of the preliminary conclusions so far reached are as follows:

In connection with the technique of form class volume table construction, considerable study has been given to the feasibility of using a form index based on the entire stem rather than on the portion above breast height. While no positive results were secured, it looks as if the simplification obtained in the manipulation of the basic tables would be offset by complications in handling reduction of breast high diameters. If a satisfactory method for using a form index based on the entire stem could be worked out, it would be possible to place the basic volume tables on a slide rule in such a way that values could be read for any form class with special diameter indices for each species.

The checking of the preliminary volume tables used in Mr. Meyer's yield study raised the question as to whether there are any consistent and significant differences in bark thickness as obtained with the hatchet and rule, which were used in 1924, and with the bark borer, which was used in 1925 and 1926. A special field study was made on this point, from which it appeared that the hatchet and rule gave bark thicknesses slightly lower than the bark borer. The differences noted, however, did not seem large enough to be of any consequence, and so no attempt has been made to separate the material according to the instrument used.

During the year there has been opportunity to discuss the theory of tree growth and the fundamental principles of tree form with Mr. Newlin of the Forest Products Laboratory and with Professor Tor Jonson of the Swedish Forest School. Mr. Newlin gave no credence to Hohenadl's compression stress hypothesis, according to which the form of a tree is developed so as best to enable it to support its own weight. He stated that Metzger's theory, according to which the form of a tree is determined chiefly by wind pressure, fitted in satisfactorily with all that he knew of timber mechanics. His most interesting comment was that tests on white ash and other species indicate that the outer layers of wood in standing trees are normally under tension, so that it would be impossible to conceive of compression on the cambium being the stimulus for new growth. On the other hand, since wood is much stronger in compression than in tension, the effect of this condition would be to give a much larger proportion of the cross section area to tension than to compression under a bending, so that this phenomenon seems to fit the tree peculiarly well to withstand wind pressure without breaking.

Professor Jonson also took little stock in Hohenadl's compression stress theory. His description of the experiments with wind tunnels now being undertaken by Mr. Tiren in Sweden in an effort to establish the validity of Metzger's theory was of particular interest Other interesting information was also secured from him as to the trend of tree form studies in Sweden.

The measurements obtained on the Cherry Mountain sample plots on the White Mountain National Forest with a view to determining what changes in form may have occurred since cutting took place on the areas some 50 years ago, have been thoroughly analyzed. Although several tendencies in form change are apparent, positive conclusions for so long a period cannot be drawn, since reconstruction of the tree tapers farther back than 20 years is so uncertain as to make the figures of little value. In general, this was shown by a rapid increase in the variability of the form quotients beyond the 20-year period, with a decided tendency for the lower form quotients to come up and the higher to come down when the trees were grouped by form quotient at the time of cutting. Averaging all the figures together showed a slight decrease in form quotient for 20 years following logging, followed by slow but steady increase for the remaining 30 years since the cutting.

Much office work remains to be done in analyzing the machine tabulations in order to work out fully all the possibilities in connection with the factors influencing the average form of standing timber, the factors affecting butt swell and bark thickness, and the comparative form of species in mixture. Whether further field data will be necessary on any of these points cannot be determined definitely until the analysis has been completed.

Preliminary work indicates that it may be possible to develop a simple formula for estimating average form class of standing timber from such readily measured stand characters as number of trees per acre and average height. The results obtained thus far, however, have not proved so reliable as the measurement of form point on a number of trees in the stand.

Additional field work is planned during the coming season on the underlying principles of tree form, and upon changing form with changing conditions, by obtaining simultaneous records of the diameter growth at breast height and at half the height above breast height. It was hoped that such records could be secured by means of dendrographs, but the cost is so high as to make this out of the question at present. Instead, a simpler and less expensive method which has been used by a Swedish forester with apparently good results will be tried out. This consists in frequent measurements of the circumference at given points with a tape, read with a vernier, and passing over supports which are fastened to the tree in such a way as to prevent scaling off of the bark, and are attached by tacks sufficiently small not to reach the cambium and therefore induce an artificial stimulation of growth.

One of the principal things to note will be the course of growth at the two points on the stem in relation to wind movement. Then, by changing the condition of the trees under observation, either by pruning the crowns or by removing surrounding trees, resulting changes in the relative growth at the two points will be obtained. The work will be carried on in cooperation with the Harvard Forest, where daily readings will be made by the men obtaining the fire weather records. There is a possibility that one of the students at the Harvard Forest may be sufficiently interested to make this project the basis for a thesis. It is hoped that another year the work can be amplified by the use of dendrographs.

Relation of Radiation (Light) and Soil Moisture to Tree Growth (T-1, P. R. Gast).

This is a fundamental investigation aimed at determining the role played by radiation (light) and soil moisture in the establishment and subsequent development of different species under various conditions. It has been conducted during the past two years in cooperation with the Harvard Forest as a joint project.

A manuscript entitle "Insolation and Silviculture: with Reference to Studies at the Harvard Forest", covering progress to date, is now in preparation. The physical background for the measurement of radiation is first sketched in detail and the present status of photochemical theory given. This is followed by a theoretical and then a practical discussion of the methods which have been suggested for the measurement of radiant energy.

Special attention is given to the development, construction, and use of the thermopiles which have been used in the present study. The novel feature of these thermopiles is that the hot junctions are spherical instead of plane, so that radiation from the total hemisphere of the sky is measured instead of merely the radiation reaching a plane surface. The use of the spherical hot junction is believed to have advantages over the plane type in ecological work, since the insolation to which trees are exposed comes from the entire sky. An attempt is being made to secure a patent on the instrument.

The thermopiles, with continuously recording multiple reading galvanometer, have been used at the Harvard Forest for two summers in measuring radiation in the open and under forest stands of different density. During four months of the first summer records were obtained (1) in the open, (2) under a closed white pine stand, and (3) under a stand originally similar to the second but from which about 60 per cent of the trees had been removed in a shelterwood cutting. Measurements on these sites were repeated during four months in 1926, and in addition records were secured during July and August in a clear-cut area and in an adjacent dense stand of mixed pine and hemlock, where the fire weather study was being conducted. Some of the preliminary conclusions so far reached may be summarized as follows:

Taking the average daily "heat-hours" (radiation intensity multiplied by time) in the open as 100 per cent, the percentage reaching the forest floor in the closed white pine stand was 30 per cent, and in the shelterwood 60 per cent. The evaporation from Livingston atmometers was 47 per cent of that in the open in the dense stand, and 60 per cent in the shelterwood.

On days of greater heat hours in the open, the number of heat hours in the forest stands was also greater, but not proportionally so. In other words, the effect of increased radiation on a brighter day is not accompanied by an equivalent percentage increase in radiation reaching the forest floor. This screening effect of the canopy, as would be expected, is the greater the denser the canopy.

Leaders from seedlings under the dense stand showed no increase in the annual growth of successive years. This apparently means that the advance reproduction under the dense stand was growing under minimally favorable conditions. Seedlings under the shelterwood stand receiving an insolation of 60 per cent of that in the opening showed an increase in the length of the leader equalling approximately 70 per cent of the increase in the open. To what extent these differences in the annual growth of leaders may be due to soil conditions is not known.

In addition to measurements of the total radiation with the thermopile and galvanometer, the uranium oxalic and photo-electric cell methods of measuring short wave length radiation have been adapted to the present study. These two methods have not been used as much as the thermopile, but many measurements have been made and checked against the thermopile, observations.

Since deviation in tissues is conditioned by the short wave lengths of radiation or their nutritional equivalent, several seedlings grown under canopies of different densities were examined to see if any effects could be found. Etiolation due to darkness is accompanied by increased cell length. Homologous portions of the white pine seedlings were therefore examined for fibre length, but no pronounced differences could be discovered. It was assumed that minimal values of radiation (or nutritional equivalent, or complementary effects of both together) were not reached.

During late August and early September, 1926, measurements of radiation with the thermopile and the uranium oxalic acid photometer were made in the spruce and hardwood sample plots at Cherry Mountain on the White Mountain National Forest.

Work on the soil moisture phase of the study has progressed far enough to show that Livingston's "rate of supply" concept is valuable. A satisfactory apparatus for the dynamic measurement of soil moisture by the "soil point" method has, however, not yet been perfected. The difficulties with the soil points so far used by Livingston are that it is hard to get a uniform contact between the soil points and the surrounding soil, and that insertion of the soil point slightly compacts the adjacent soil.

In order to get around these difficulties Mr. Gast conceived the idea of using "soil "wells", consisting of porcelain discs placed in bakelite holders which would be left permanently in the soil. By placing another porcelain disc in the soil well, the rate of water transferred from the soil to the first disc and thence to the second disc could be measured by weighing the latter before and after insertion. Porcelain discs for this purpose were obtained without cost through the courtesy of the General Electric Company and were ground to a fairly smooth face.

Two difficulties were encountered with this apparatus. First, the capillary contact between the two porcelain plates was not satisfactory, and second, the porosity of the porcelain was not uniform. An unsuccessful attempt was made to secure a specially constructed pulp block to take the place of the inserted porcelain disc ("plunger"). Preliminary experiments with "fritted glass" to overcome the difficulty presented by the varying porosity of the porcelain showed that this material has possibilities. Sketches were made for a well and plunger both made of fritted glass, but funds for the construction of the apparatus have not been available.

Radiation measurements with the thermopile, the uranium oxalic acid photometer, and the photo-electric cell will be continued in the clear-cut area and in the adjacent white pine-hemlock stand at the Harvard Forest which were studied in 1926. During the latter half of June similar measurements will be taken on the Cherry Mountain plots on the White Mountain National Forest, in order to make possible a comparison on these plots between the amount and character of radiation toward the end of the summer (August and September) and at the height of the growing season (the latter half of June).

Since analysis of the fire weather data at the Petersham station shows that radiation measurements show a definite correlation with duff moisture, provision will be made for incorporating them as a regular part of the work.

A further attempt will be made to secure satisfactory porcelain or fritted glass for the "rate of supply" method of measuring soil moisture. Soil moisture determinations by the usual "static" methods will also be carried on in relation to the fire weather study. Satisfactory apparatus for the measurement of soil moisture by the dynamic method is greatly needed for the study of this important ecological factor, so that continued efforts in this direction are well worth while.

Weather and Fuel Relationships (Pf. B-5, S. T. Dana and P. W. Stickel).

The object of this project is to determine for various forest types and forest conditions the relation between weather conditions and the inflammability of forest fuels. Work was started in 1925 on the Pack Demonstration Forest of the New York State College of Forestry at Cranberry Lake, N. Y., in adjacent areas, one of which had been cut clear in 1921 and is now covered with blueberries and other low shrubs; while the other was culled for softwoods at the same time and is now covered with a fairly dense stand of mature northern hardwoods. Readings on these areas were made five times a day from the middle of July to early October of air temperature, air humidity, wind movement, evaporation, barometric pressure, duff and soil temperature, and duff moisture.

Cooperation from the New York State College of Forestry, the Harvard Forest, and the Empire State Forest Products Association made it possible to expand the field work materially in 1926. The station at Cranberry Lake, New York, was continued, and two additional stations were established, - one in the white pine type on the Harvard Forest at Petersham, Massachusetts, and a second at Elk Lake, New York, in the spruce slope type.

In each case records were obtained on a clearcut area, representing the maximum fire hazard, and in an adjacent uncut area, representing the minimum hazard for the type concerned. The number of daily observations was reduced from five (as taken in 1925) to four, - at 8 A.M., 11 A.M., 2 P.M., and 5 P.M. This was found to be advantageous not only because the observer was given more time for other work, but also because a reading was obtained at 2 P.M., which usually represents the hottest and driest time of the day. The six months' record at Petersham, from May to November, was the longest obtained last year. At Cranberry Lake, a five months' record, from June to October, was obtained; while at Elk Lake the station was maintained for only three months, from July to September.

Petersham proved a particularly advantageous location for a fire weather station because of the possibility of making use of the light records being secured in the project dealing with light in relation to tree growth (T-1). In addition to daily observation of the most important meteorological factors and of duff moisture, work was done here on the inflammability of white pine duff with various percentages of moisture content. The three fire brands used were matches, pipe heels, and cigarettes. It had been hoped that, by using an electrical hot wire apparatus, the data secured from such empirical methods would be strengthened. Such an apparatus would give not only the temperatures generated by fires but also the heat units in calories necessary to raise the fuels to the combustion point. Due to mechanical difficulties in getting the hot-wire apparatus built, this instrument could not be used in 1926. It is now ready, and will be used this coming year.

The Zeleny Moisture Meter, which it was thought might be used in measuring duff moistures, proved to be unfit for this work. The meter is most useful for measuring moisture contents above 50 per cent. When working from absolute dryness towards higher moisture contents, the instrument did not commence to give readings until the moisture content reached 15 per cent. Recently the Forest Products Laboratory has perfected an electrical apparatus for measuring the moisture content of wood, which is based upon the fact that the electrical capacity of wood varies with its moisture content. It is hoped that this apparatus can be adapted to the determination of duff moisture content and tried out during the coming year.

The outstanding points of interest which the fire weather study has developed to date are the close relationship between weather conditions and fire hazard, the importance of precipitation, relative humidity, and duff temperatures in relation to duff moisture, and the zones of inflammability in white pine duff under various moisture contents.

When the Petersham records for 1926 are compared with the record of forest fires in central Massachusetts, a distinct correlation is noted. In general, relative humidities below 50 per cent are dangerous except within rainy periods. During the spring fire season, about 50 per cent of the days had relative humidities of 50 per cent or less, and on these days 81 per cent of the fires occurred and burned over 99 per cent of the area burned.

Up to the present time, the factor of duff temperature and its effect upon duff moisture has not received much consideration; yet under certain conditions duff temperature is fully as important as relative humidity. This was brought out strikingly in the preliminary examination of the Petersham records. Duff temperatures of as high as 140 degress F. were not at all uncommon for this area, while at Elk Lake duff temperatures as high as 160 degrees F. were recorded. At Petersham, where the records extend from the spring season to the fall season, it was found that while in the fall relative humidity readings were as low as those which occurred in the spring, the duff moisture did not fall as low as in the earlier part of the year. This is probably because of the lower duff temperatures in the fall.

The inflammability tests, while not yet sufficient in number to be conclusive, do indicate definite zones of inflammability in the white pine duff. When the duff moisture content is 10 per cent or less, all fire brands are dangerous, and fires can be started with matches, pipe heels, and cigarettes. From 10 to 15 per cent, matches and pipe heels were effective in starting fires; from 15 to 25 per cent, only matches would start fires; while above 25 per cent there is little danger from any of the fire brands used. In connection with this work it was surprising how low the duff moisture fell. Duff moisture readings of 2 per cent in the white pine type at Petersham were frequent, expecially in the late spring and early summer. This inflammability work will be continued this year, and probably extended to other forest types. The hot-wire apparatus will be used to secure more exact information, especially as to temperatures created by going fires and the calories required to start fires.

For the coming field season, it is planned to continue work at Cranberry Lake, Elk Lake, Elk Lake, and Petersham, and to establish a new station in north central Maine with the cooperation of the Forest Commissioner of Maine. Observations at each station will be continued, if funds are available, until it is reasonably certain that weather records have been secured not only for average but for abnormally wet and abnormally dry seasons. With the intensive educational campaign against forest fires now being conducted on Cape Cod, it would be very valuable if a fire weather station could be placed there, but lack of funds will probably make this impossible. An additional station there, in the sprout hardwoods region of Connecticut, and in the Allegheny hardwoods region of southern New York, are needed to cover adequately the principal forest regions of the Northeast.

Prediction of Fire Hazard (Pf, C-7, F. C. Crombie).

The object of this study is to work out methods for predicting the occurrence of fire weather more accurately and for longer periods than is now possible. It is primarily a Weather Bureau project in which the Experiment Station is, however, vitally interested because of its intimate connection with the study of the relation between weather conditions and fire hazard, which must, of course, furnish the basis for translating weather predictions into terms of actual fire hazard for specific types and forest conditions.

In the winter of 1925 a tentative plan was worked out by the section director of the Weather bureau at Boston and by the director of the Northeastern Forest Experiment Station for fire weather forecasting in central and northern New England. Under this plan the section director, Mr. G. A. Loveland, agreed on request to issue special daily fire weather forecasts to the state foresters of Maine, New Hampshire, Vermont, and Massachusetts, and to the supervisor of the White Mountain National Forest. For this purpose, each state was divided into two or more sections for which the forecasts were to be made separately.

The essential points in which such forecasts were to differ from the regular Weather Bureau forecasts were that they were to be more detailed, to cover as long a period in advance as possible, and to indicate the degree of confidence which should be placed in any given forecast. Thus, "strongly indicated" used in connection with any particular factor, such as temperature, means that the chances that the forecast will be correct are 90 to 100 per cent; "indicated" that the chances are 70 to 80 per cent; and "unsettled, probably" that the chances are 50 to 60 per cent. At the same time, arrangements were made for the establishment of a few additional meteorological stations in Maine and New Hampshire, and for reports from fire wardens and lookout observers as to the daily character of the weather during the preceding week.

A few forecasts were issued under this arrangement in 1925 and 1926, but the lack of a man who could devote his entire time to the fire weather forecasting made it difficult both to systematize the work properly and to establish the personal contacts with the state foresters necessary to arouse and maintain their interest in the work. During these two years fire weather forecasts for Connecticut were issued direct to state fire wardens by Mr. Tarr, the Weather Bureau official in charge of the New Haven office. Arrangements were also worked out in New York State by which first Mr. Todd, and after his death Mr. Lindgren, cooperated with the Superintendent of State Forests in advising him on the subject. Several additional meteorological stations were established in the Adirondacks in 1926, from which daily telegraphic reports were forwarded to the Weather Bureau official at Albany.

In the fall of 1926 the Weather Bureau assigned Mr. F. C. Crombie to devote his entire time to the study of fire weather forecasting in the Northeast. The primary object of his work is to make it possible to predict more accurately and for longer periods in advance just when "fire weather", as determined by the study of the relation between weather and fire hazard (Pf, B-5), is likely to occur. At present he is making his headquarters at the Weather Bureau office in Boston, where his work is carried on in close cooperation with the state foresters and the Northeastern Forest Experiment Station.

His first work was to establish personal contacts with the state foresters and others interested in the project in the region and to agree with them on plans for the work. A careful study of the existing meteorological stations in the region made it clear that these are not adequate for his purpose, particularly in the more heavily forested parts of the region. He has, therefore, made arrangements for the establishment of additional stations in all of the New England states except Rhode Island, from which telegraphic reports will be transmitted to the Boston office of the Weather Bureau daily immediately after the morning reading. The Bureau will then be able, by using these records in combination with those obtained regularly by the Weather Bureau from all parts of the country, to send out fire weather forecasts to the state foresters and to the supervisor of the White Mountain National Forest in time to reach them not later than 11 A. M. Forecasts for Connecticut and New York will continue for the present to be made by the Weather Bureau officials at New Haven and Albany.

While the Bureau thus plans to take up at once the forecasting end of the work, it is clearly recognized that a great deal of research will be necessary to give these forecasts the desired accuracy, particularly for longer periods than is now possible. It is particularly important that administrative officers should appreciate the need of further study, both of the forecasting end of the work and of the relation between weather conditions and actual fire hazard in different types and forest conditions, so that they will not be disturbed if the first forecasts fall considerably short of perfection. Eventually, through a continuation of the work now under way on these two projects, it is hoped that it may be possible to issue daily forecasts both by telegraph and by radio, expressed not only in terms of meteorological conditions, but also of actual fire hazard under specific conditions in different parts of the region.

Analysis of Forest Fire Statistics (Pf. D-2, S. T. Dana and P. W. Stickel).

This project involves an intensive analysis of available records in order to secure as complete and accurate information as possible in regard to forest fire hazard, risk, and damage in various parts of the Northeast. Special attention is being paid to the relation between number and size of fires, damage, and cost, and such factors as cause, location, date, elapsed time, weather conditions, forest type, method of cutting and slash disposal, etc. As a means of improving present records a conference of Northeastern state foresters and representatives of the Forest Service was held at Boston in January, 1926, which resulted in an agreement on the essential items which should hereafter be included in all forest fire reports.

Financial cooperation from several of the state foresters has made it possible to expand the work considerably during the past year. Records have now been coded, placed on punch cards, and run through the electrical tabulating machine as follows: Maine, 1915 to 1926; New Hampshire, 1924 and 1925; Vermont, 1909 to 1926; Massachusetts, 1923 and 1924; and Connecticut, 1921 to 1925. Unfortunately, the Station's allotment has been insufficient to enable it to undertake thoroughgoing studies except in those states in which its own contribution to the work could be supplemented by financial assistance from the state concerned.

A preliminary report on forest fires in Connecticut from 1921 to 1925 has been submitted to the state forester of Connecticut and published in somewhat abbreviated form in his latest biennial report. One of the most striking facts brought out in this report is that more than two-fifths of the fires in Connecticut come in the month of April, and more than three-fourths in March, April, and May. This holds true so uniformly for each of the five years under consideration as to leave little doubt that it is thoroughly characteristic.

The area covered by the early spring fires is fully as striking as their number. Thus in 1922, which was by far the worst of the five years under consideration, nearly 80 per cent of the fires occurred in March, April, and May, and this 80 per cent burned 98½ per cent of the total area burned during the entire year. Even in 1924, which was characterized by one of the dryest Octobers and Novembers ever known, with rain on only two days in the entire month of October, April and May still held the record both as to number of fires and area burned.

The very small number of fires from June to September is fully as striking as the large number in April. July, August, and September show less than 3 per cent of the total number of fires for the year as a whole, and June, July, August, and September only 5.5 per cent. September is apparently as safe a month from the standpoint of forest fires as is February, only 0.4 per cent of the total number of fires for the entire year occurring in each of these months. Not in a single county in the state did the number of fires for the five years under consideration average as high as one per month for either February or September. During the entire five years only three fires occurred during the first ten days of September, and the same number during the first ten days of July. This is particularly surprising in view of the fact that two holidays - Labor Day and the Fourth of July - are included in these periods.

These figures show clearly the possibilities of saving on fire control expenditures during the summer months and the great difficulty of meeting the extremely heavy load in the spring. The comparative safety of the summer months is undoubtedly due to the condition of the forest at that time rather than to climatic conditions. For example, April, 1924, with an excess precipitation of 2.35 inches, had 36 per cent of the total number of fires for that year and 39 per cent of the area burned; while July, 1924, with a deficient precipitation of 3.61 inches had only 6 per cent of the total number of fires and only 2 per cent of the area burned.

In midsummer the heavy foliage on the trees, by preventing evaporation within the forest, keeps it both moister and cooler than in either spring or fall. The greatest danger comes in spring when the days are steadily growing warmer and before the foliage is fully out. In the fall, conditions again become dangerous when the leaves are off the trees, but less so than in the spring because of the shorter days and the cooler temperatures. November is undoubtedly more dangerous than October, in spite of its greater coolness, because of the fact that the leaves have more completely fallen by that time.

Some interesting facts developed in connection with the location of fires, particularly from the standpoint of population. The most densely populated counties have the greatest actual number of fires, but also the smallest number in proportion to their population. Thus, the three most densely populated counties averaged four fires for every 10,000 of population during the five years under consideration; while the five less densely populated counties averaged 13.3 fires per 10,000 of population for the same period. Moreover, the individual fires are smaller, and the area burned in per cent of forest area much less, in the densely populated counties.

More fires occur between noon and 3 P.M. than at any other hour of the day. For the five years under consideration, 39 per cent of the fires whose time of origin is known started during these three hours, and burned 48 per cent of the total area burned. This is undoubtedly due to the fact that the morning and early afternoon fires occur while the temperature is still rising and the humidity decreasing, and are, therefore, much more dangerous than those starting after the middle of the afternoon when the weather is usually becoming both cooler and moister. This points to the need for greater care in the use of fire, for example in brush burning, during the first half of the day, and perhaps to the withholding of burning permits until late afternoon.

A preliminary report on forest fires in New Hampshire in 1924 and 1925 was submitted to the state forester for inclusion in his biennial report. He felt, however, that the period covered was so short and some of the conclusions reached so startling as to make it wise to defer publication until figures were available for a longer period. The concentration of fires in the southwestern or industrial part of the state was very clearly brought out, as was also the concentration of the fire danger in spring and fall. The summer months are, however, clearly more dangerous than is the case in Connecticut.

Another much more striking contrast with Connecticut is the much smaller number of fires, their smaller average size, and the smaller area burned. Thus, in New Hampshire for the two years 1924 and 1925 the per cent of forest area burned by counties varied from 0.008 to 0.644 per cent, with an average of 0.121 per cent, while in Connecticut the range was from 1.58 to 3.63 per cent ,with an average of 2.54 per cent. On the other hand, on the basis of population Connecticut's record was slightly better, with an average of 6.1 fires for every 10,000 of population as against 8.2 fires for every 10,000 of population in New Hampshire.

Reports for publication as state bulletins are now being prepared for Maine, Vermont, and Connecticut. If time and funds permit, the New Hampshire fire records from 1921 to 1923 will be coded and tabulated, and a special report prepared for the five years from 1921 to 1925. The Massachusetts fire records for 1923 and 1924 will be analyzed, but it is doubtful whether the Station's resources will permit covering a full five-year period, particularly in view of the very large number of fires each year in the state. No detailed work on fires in Rhode Island or New York appears feasible in the near future.

In addition to the state bulletins, a Department bulletin covering the region as a whole as thoroughly as the available records permit will be prepared for publication during the coming year. It is planned as soon as funds are available, either from the Station's own allotment or from cooperative sources, to complete a thoroughgoing analysis of fires for the entire region at least as far back as 1921, and also to keep current records up to date from now on. This will furnish a detailed body of fire data in convenient form for thoroughgoing analysis which will become of steadily increasing value as the years go by.

Control of the White Pine Weevil (Pi-4, H. J. MacAloney).

The object of this project is to determine practical and effective measures for the control of the white pine weevil. Field work was started in 1925 and has been along three main lines: first, the obtaining of additional information regarding life history, with special reference to hibernation and flight; second, the important parasites and predators attacking the weevil, with special reference to the possibility of artificially increasing their numbers; and third, the effect of ecological conditions, particularly density and mixture, on weevil damage and control. Nearly 3,000 infested leaders have been collected for the breeding of parasites, and about 175 permanent and semi-permanent sample plots have been established.

Field work during 1926 carried the investigation far enough so that a few preliminary conclusions are justified. These have been embodied in a report which has been distributed to those particularly interested in the project. While a cure-all still seems unlikely, further study shows that much can be expected both in controlling the weevil itself and in decreasing the injury to the tree through silvicultural measures.

Considerable time has been spent in the study of parasites and predatory agents. Twenty-five species of parasites have been bred from leaders collected during the summer of 1925, of which five appear to be of primary importance. While these offer some promise in reducing the numbers of the weevil, their effectiveness in materially decreasing damage by it is very doubtful. There are many difficulties in the way of breeding and liberating a sufficient number of parasites to be effective even over a limited area, and the cost would also be excessive. It is, however, worth while when weeviled leaders are removed to place them in screened barrels so as to allow the escape of the parasites. When this is done, it has been found that No. 12 or No. 14 mesh wire is more satisfactory than No. 16, as heretofore advised. A No. 12 mesh wire will allow the escape of all the important parasites, and while a few of the very smallest of the weevils will also escape, it is believed that the additional liberation of parasites will more than offset this.

Birds are evidently of more value than parasites in controlling the weevil. In one plantation at Petersham covering over three acres, 30 per cent of the weeviled leaders had been stripped by birds and all the larvae destroyed. The birds actually observed feeding were the nuthatch, downy woodpecker, chickadee, and certain warblers, but it is probable that other insectivorous birds also feed on the weeviled larvae. Protection of insectivorous birds is, therefore, important as a control measure.

Experiments with banding trees with tanglefoot indicate that weevils may reach the leader either by flying directly to it, by flying to some other part of the tree and then crawling to the leader, or by crawling up the stem from the ground. Banding with tanglefoot just below the leader, therefore, prevents attack in the two latter ways, but is too expensive to be generally used. Weevils were observed to be flying both in the fall and in the spring, but only on warm days when the temperature was 70 degrees Fahrenheit or more.

The height up to which weeviling may occur was studied in some detail during the past season. About one-half of the weeviling occurs before the trees are 30 feet in height. Trees may be weeviled above 80 feet, but after a height of 60 feet is reached, the weeviling is unimportant. Weeviling in widely spaced, pure stands seems to be most prevalent at about 17 to 20 feet, gradually falling off till at 60 feet and over less than one per cent of the trees are weeviled.

Spraying with lime sulphur has been tried out with success, but is too expensive for general use.

Much attention has been paid to control of the weevil by forest management. Altogether, 27 permanent and 150 semi-permanent sample plots have been laid out for this purpose, not including about 70 taken in New York prior to May, 1925. Previous observations to the effect that pine in pure stands and in stands of low density are most severely attacked have been repeatedly corroborated. It has generally been assumed that mixed stands suffer less because the pine is shaded from the sun and the surrounding trees act as a barrier against flying. These reasons partly explain the small amount of infestation in such stands, but the fact that groups of pines surrounded by hardwoods are not weeviled to any extent, even though pure stands nearby have been weeviled repeatedly, indicates that there are other reasons. Experiments with caged weevils, which fed chiefly on leaders from pure pine stands, although leaders of practically identical appearance and vigor from mixed stands were present, suggest that there may be something in the latter which repels the insects.

From the work so far done, it appears that the most advantageous and cheapest way to protect white pine from the weevil and to control the injury is to grow it in mixture, preferably with species that will be of value in the final crop, such as hemlock and the better hardwoods. Weedings in the early stages, if the mixture is with hardwoods, and thinnings as the stand becomes older, will be necessary to prevent the white pine from being crowded out. Information is now particularly needed as to just what mixtures and just what densities offer the best protection. Attention from now on will be concentrated on this phase of the study, although observations on parasites and life history will be continued in connection with it.

This decision is in accordance with the recommendations made by a group of those interested in the weevil investigation who met at Philadelphia in December, 1926, in connection with the winter meeting of the American Association for the Advancement of Science. The conference was called at the suggestion of the Northeastern Forest Research Council and included representatives from Canada, Maine, Vermont, Connecticut, and the Northeastern Forest Experiment Station. Those present agreed that the essential facts in the life history of the insect are now well known; that sufficient experiments have been tried out with direct control and biological control measures to indicate that these are too expensive and uncertain to permit of application over large areas; and that particular emphasis should now be placed on control of the weevil by improved silvicultural practice.

The probable discontinuance of the financial cooperation of $2,500 a year previously received from interested timberland owners will make it necessary to curtail field work during the coming year. Mr. MacAloney will spend a considerable part of the summer in Canada working on the same study for the Entomological Branch of the Dominion Department of Agriculture, which will take care of both his salary and expenses during this period. Necessary observations on the sample plots at Petersham and vicinity will be carried on in his absence by Mr.

Hall.

Cooperation in the obtaining of sample plot data has been received during the past year from the Vermont Department of Agriculture. A study of the weevil has also been started by the New Hampshire Agricultural Experiment Station. It is expected that cooperation will be received during the coming year from these two agencies, and perhaps in addition from the Connecticut Agricultural Experiment Station.

Minor Projects.

In addition to the information concerning the minor projects contained in the project status sheets, information as to progress so far made and future plans may be summarized briefly as follows:

Source of Seed - Scotch Pine (Fs-d-1, M. Westveld).

Four half-acre plots were planted on the Mount Toby Forest of the Massachusetts Agricultural College in the spring of 1924 to determine (a) the relative desirability of stock raised from Scotch pine seed of Austrian and Baltic origin for planting in the Northeast; (b) the relative development of Scotch pine, red pine, and white pine on the same site; and (c) the feasibility of inter-planting Norway spruce for Christmas tree stock in mixture with pine.

Measurements of the survival and height growth on the different plots have been made each year, and fail places filled in with stock of the same age. Measurements will be continued indefinitely, and any additional fail places filled for at least another year or two, in order to keep the plantation fully stocked. The plots are, of course, not yet old enough to yield any definite results.

Management of Sprout Hardwood Stands (M-2, M. Westveld).

This project has so far been limited to the establishment in 1924 of five permanent sample plots on adjacent burned and unburned sprout hardwood land on the Simsbury State Forest, Connecticut, to determine the influence of fire on reproduction and growth in stands of this character. The plots were remeasured in 1925 and inspected in 1926; and will be remeasured in the spring of 1927. At that time, one of the three burned plots will be reburned in order to determine the effect of repeated burning of the same land. Perhaps the most striking result of the study to date is the high mortality of hardwood sprouts caused by a single fire.

Replacement of Chestnut (M-3, P. W. Stickel).

Two quarter-acre permanent sample plots were established in 1924 on the Mount Toby Forest on areas where the blight-killed chestnut had been removed and white pine planted, in order to follow the natural development of such areas and to determine the feasibility of converting them to white pine. In 1925 all of the hardwood sprouts on one plot were weeded in order to favor the white pine, while the other was held as a check plot. Both plots were remeasured in 1925 and 1926 and will be remeasured in 1927, when further weeding will if necessary be done on the plot weeded in 1925. A third quarter-acre plot will be established if possible in 1927 in an area where the dead chestnut is still standing to observe natural reproduction under this conditions.

In connection with this project, a survey of blight-killed areas in southern New England was made in cooperation with the Appalachian Forest Experiment Station. The results of this survey have been submitted for publication in the Journal of Agricultural Research and as a Department of Agriculture circular.

Management of Eastern Hemlock (M-4, C. E. Behre).

In 1924 three quarter-acre sample plots were established on the Mount Toby forest to determine (a) the effect of cutting on advance reproduction of hemlock, and (b) the desirability of filling in openings on the cut-over area by the planting of red pine and white pine. One of the plots was planted to red pine, another to white pine, and the third held as a check without planting. Brush was scattered on one-half of each plot and removed on the other half.

In 1926 a cleaning of the hardwood sprouts was made in both the planted plots. To date, there has been little mortality in either the residual hemlock or the planted pine, both of which are developing well. Annual observations of the plots will be continued, and another cleaning of hardwood sprouts probably made in 1928.

Pruning of White Pine (Mp-1, P. W. Stickel.)

Press of work has so far made it impossible to start work on this project, the object of which is to determine the effect of pruning on white pine at various ages and in stands of various densities. Three quarter-acre sample plots will be established in 1927 on the Mount Toby Forest, of which one will be pruned the same year, a second several years later, and the third left intact as a check plot. Additional plots covering different conditions and different conditions and methods of pruning will be established later, as opportunity offers.

Permanent Sample Plots (M-5, C. E. Behre).

This project involves the maintenance of 74 main plots and 45 reproduction plots which were established in 1905 prior to the organization of the Northeastern Forest Experiment Station, and which have been retained by the Forest Service. Remeasurements of most of these plots were completed in 1925 and 1926. Many of the plots are now old enough so that data of considerable value is being obtained from them. The figures are being worked up in cases where they are of immediate value in connection with any of the major projects now under way at the Station, and will be worked up for the other plots as rapidly as opportunity permits.

Chestnut Blight (Pd-1, P. Spaulding).

This project involves a study of all phases of the chestnut blight, with special emphasis on the feasibility of perpetuating the native chestnut by the development of resistant varieties or of replacing it by other resistant species or hybrids. During the past two years widespread inquiry has been made among foresters and botanists with a view to obtaining information as to the location of any apparently blight resistant trees. This has resulted in several interesting leads and in the establishment of a number of useful contacts. It appears to be too early to find many markedly resistant trees in the Northeast, because of the abundance of diseased but still living trees. As these become scarcer, any really resistant trees will become much more evident, even to the casual observer.

The contacts already established will be maintained and the investigations under way continued indefinitely. The project should be classed as a major one from the standpoint of its intrinsic importance and is placed in the group of minor projects only because of the fact that its present status does not require any large amount of current work.

Research on White Pine Blister Rust (Pd-2, P. Spaulding).

This project involves the continuation of studies of the life history, epidemiology, and other scientific aspects of the white pine blister rust, which have been under way since 1909.

Pitch Pine Blister Rust (Pd-3, P. Spaulding).

This project involves the continuation of work started in 1909 to determine the behavior of the native pitch pine blister rust in comparison with the very closely related but introduced white pine blister rust.

Control of the Bronze Birch Borer (Pi-6, H. J. MacAloney and R. C. Hall).

The object of this project is to determine practical measures for the control of the bronze birch borer by forest management. In 1926, several areas in New Hampshire and Vermont which were examined showed striking evidence of the very considerable damage done by this insect, particularly in mature and thinned stands.

In 1927, sample plots will be established and other studies conducted to determine the relation between the severity of the injury and the character of the stand and of the individual trees attacked. Information will also be secured on the life history of the borer, including its possible relation to the activity of a canker (apparently a species of NECTRIA) which is doing much damage to yellow birch in Vermont

Practice of Forestry by Private Owners (M-1, WO, Staff).

This is a continuing project for all of the forest experiment stations. It aims (a) to obtain, whenever opportunity offers, information as to the extent to which forestry is being practiced by private owners, the general character of the work being done, and the results secured; and (b) to encourage the practice of private forestry by personal contact, correspondence, general publicity, publications, and demonstrations.

Regional Yields (ME-1, WO, Staff).

This is another continuing project for all of the forest experiment stations. Its object is to bring together systematically, as opportunity offers, all available data on the present and potential growth and yield of different species and forest types. Information is being obtained currently in connection with several of the Station's more specific projects.

Converting Factors (ME-2, WO, Staff).

This also is a continuing project for all of the forest experiment stations. Its object is to bring together systematically, as opportunity offers, information upon converting factors used for converting timber measured in one unit into another unit. Piling tests will be conducted in 1927 in connection with the spruce yield study to determine the actual solid contents in stacked cords from second growth spruce stands of different average sizes.

Manual on Forest Measurements (ME-3, WO, Staff).

This project involved cooperation with a special committee consisting of representatives from the Forest Service, the Society of American Foresters, and the Association of State Foresters, which was organized in 1924 to prepare a manual on forest measurements, with special reference to securing uniformity, so far as practicable, through the adoption of standard methods. This work has been completed, and the final report of the committee was published in the Journal of Forestry for October, 1926, under the title "Methods for Preparing Volume and Yield Tables". The project is, therefore, being dropped from the Station's program.

Manual of Field Methods (ME-4, WO, Staff).

This is another project being handled by a special committee consisting of representatives from the Forest Service, the Society of American Foresters, and the Association of State Foresters which was organized in 1926. Its object is to prepare a manual covering the methods used in field studies, and particularly in sample plot work, in order to obtain more comparable results from studies undertaken by different agencies and in different forest regions through greater uniformity in the collection, compilation, and analysis of field data. The Northeastern Forest Experiment Station participates in the project as requested by the committee. So far, an outline of the proposed manual has been reviewed and commented on in detail. Similar action will be taken with various sections of the manual as rapidly as they are received from the committee.

It will be noted that most of the minor projects involving repeated field measurements are located within easy reach of Amherst. This makes it possible for field work on them to be handled in early spring before field work is possible in the northern part of the region, where most of the Station's major projects are centered. While the number of minor projects seems large, they are, nevertheless, so located and the amount of time devoted to them is so restricted as to prevent any serious interference with the execution of the Station's major program.

New Projects.

The only new project proposed for the coming year is the determination of evaporation by the Bartes' evaporimeter (T-2, P. W. Stickel). This work was suggested by Mr. Bates as a means of obtaining comparable, year-long information on evaporation in different forest regions in connection with studies of forest types, and seemed to be worth undertaking. Ten-day records of evaporation are being obtained with one pair of evaporimeters near the headquarters of the Experiment Station in Amherst, and with another pair at the New York State Ranger School, Wanakena, N. Y., which is cooperating in the study.

The amount of work involved is so small as hardly to justify designating it as a separate project. Since it does not, however, fit in very closely with any other project, it is thought best to give it a project number in order to record the fact that the study is under way and to provide a filing place for material connected with it.

Publications.

Last Year.

The following papers by members of the staff have been published during the past year.

Those marked with an asterisk (*) were listed in last year's investigative program as having been submitted for publication, but had not actually appeared in print at that time.

"Forest Research in the United States", by S. T. Dana.
Published as Report #71, World Forestry Congress; also reprinted in Vol. 5, No. 2, of the Empire Forestry Journal.* 7 pp. Dec 1926

"The Mission of Forest Research", by S. T. Dana.
Published in Journal of Forestry for October, 1926.* 7 pp.

"Forest Fires and Recreation", by S. T. Dana.
Published in American Forests and Forest Life for September, 1926. not indexed

"The Editor's Silver Jubilee", by S. T. Dana.
Published in Journal of Forestry for December, 1926. 2 p

"World Forestry Congress", by S. T. Dana.
Published in Journal of Forestry for January, 1927. 1p. illus.

"Forestry and the Society", by S. T. Dana.
Published in Journal of Forestry for February, 1927. 5 pp.

"Forest Fires in Connecticut, 1921-1925", by S. T. Dana.
Published in the Report of the Connecticut State Park and Forest Commission for 1925-1926. 9 pp.

"European Forest Experiment Stations", by S. T. Dana.
Published in Yale Forest School News for January, 1927. 6 pp.

"Weather Injury to Terminal Buds of Scotch Pine and Other Conifers", by H. C. Belyea and H. J. MacAloney.
Published in Journal of Forestry for October, 1926.* 5 pp.

"The White Pine Weevil Problem in the New England States", by H. J. MacAloney.
Published in the Proceedings of the Forest Protection Conference, Syracuse, N. Y., November, 1926.

"Methods of Reading Multiple Quantities from Curves", by W. H. Meyer.
Published in Journal of Forestry for May, 1926.* 4 pp

"Influence of Physical Factors on the Viability of the Sporidia of Cronartium Ribicola Fischer" by P. Spaulding and Annie Rathbun-Gravatt.
Published in the Journal of Agricultural Research for September 1, 1926. 37 pp.

"The White Pine Blister Rust in Germany", by P. Spaulding.
Published in the Journal of Forestry for October, 1926. 8 pp.

"The Role of Fungi in the Disposal of Slash", by P. Spaulding.
Published in the Proceedings of the Forest Protection Conference, Syracuse, N. Y., November, 1926.

"The Importance of Meteorology in the Study of Forest Fire Prevention", by P. W. Stickel. Published in the Proceedings of the Forest Protection Conference, Syracuse, N. Y., November, 1926.

"Logging Damage to Spruce and Fir Reproduction", by M. Westveld. Published in Journal of Forestry for May, 1926.*

Next Year.

Present plans contemplate publication of the following papers by members of the staff during the coming year. Those marked with an asterisk have already been submitted and are now being finally revised or are in process of publication.

"Form Class Taper Curves and Volume Tables and Their Application", by C. E. Behre. Estimated length 30 printed pages plus 17 tables and 28 figures. Suggested for publication in Journal of Agricultural Research, to which it has already been submitted.*

"Application of Form Class Volume Table System to Red Spruce, White Spruce, and Balsam Fir", by C. E. Behre. Estimated length 30 printed pages plus 10 tables and 10 figures. Suggested for publication in Journal of Agricultural Research. Ready for submission in winter of 1927-28.

"Preliminary Yield Tables for Western Yellow Pine in the Inland Empire", by C. E. Behre. Estimated length 15 printed pages plus 10 tables and 15 figures. Suggested for publication by Idaho School of Forestry or in Journal of Agricultural Research. Ready for submission in summer of 1927.

"Timber Growing and Logging Practice in the Northeast", by S. T. Dana. Estimated length 40 printed pages. Suggested for publication as a Department Bulletin. Ready for submission in spring of 1927.*

"Forest Experiment Stations - Their Development and Future", by S. T. Dana. Estimated length 20 printed pages. Suggested for publication in Journal of Forestry. Ready for submission in fall of 1927.

"Forest Fires in Maine, 1915-1926", by S. T. Dana. Estimated length 15 printed pages 6 tables and 6 figures. Suggested for publication as a bulletin of the Maine Forest Service. Ready for submission in spring of 1927.

"Forest Fires in New Hampshire, 1921-1925", by S. T. Dana. Estimated length 12 printed pages plus 6 tables and 6 figures. Suggested for publication as a bulletin of the New Hampshire Forestry Commission. Ready for submission in spring of 1927.

"Forest Fires in Vermont, 1909-1926", by S. T. Dana. Estimated length 12 printed pages plus 6 tables and 6 figures. Suggested for publication as a bulletin of the Vermont Forest Service. Ready for submission in spring of 1927.

"Forest Fires in Connecticut, 1921-1925", by S. T. Dana. Estimated length 12 printed pages plus 6 tables and 6 figures. Suggested for publication as a bulletin of the Connecticut State Park and Forest Commission. Ready for submission in spring of 1927.

"Forest Fires in the Northeast, 1921-1925", by S. T. Dana.
Estimated length 30 printed pages plus 10 tables and 10 figures. Suggested for publication as a Department bulletin. Ready for submission in summer of 1927.

"Insolation and Silviculture, with Reference to Studies at the Harvard Forest", by P. R. Gast
Dissertation for a D.S. degree. Suggested for publication in revised form by the Harvard Forest or in the Journal of Agricultural Research. Estimated length of revised draft 20 printed pages plus 10 figures. Ready for submission in fall of 1927.

"Studies in the Humus Layers of Coniferous Forests, Their Peculiarities and Their Dependence on Silviculture", translation by P. R. Gast and P. W. Stickel of the Summary of a paper by Henrik Hesselman in Vol. 22, No. 5 of the Contributions of the Swedish Forest Experiment Station. Length about 90 double spaced typewritten pages. Already submitted for mimeographing.

"Yields of Second Growth Spruce and Fir in the Northeast", by W H. Meyer.
Estimated length 20 printed pages plus 45 tables and 20 figures. Suggestion for publication as a Department bulletin. Ready for submission in summer of 1927.*

"Application of Normal Yield Tables to Abnormal Stands", by W. H. Meyer.
Estimated length 8 printed pages plus 2 tables and 2 figures. Suggested for publication in-Journal of Agricultural research, as a Department circular. or in Journal of Forestry. Ready for submission in summer of 1927.

"The White Pine Blister Rust in Europe and Conditions Affecting It", by P. Spaulding.
Suggested for publication as a Department bulletin. Ready for submission in spring of 1927.

"Decay of White Pine Slash", by P. Spaulding.
Suggested for publication as a Department bulletin. Ready for submission in spring of 1927.

"A Preliminary Investigation of the Disposal of White Pine Slash", by L. S. Altpeter and P. Spaulding.
Summary of Spaulding's Department bulletin to be included in a proposed Harvard Forest bulletin.

"A Sketch of the History of the Forest Tree Nursery Trade Between Europe and America as Exemplified by the Eastern White Pine", by P. Spaulding.
To be published in Proceedings of Agricultural History Society.*

"Natural Replacement of Blight-Killed Chestnut in the Forests of the Northeast", by C. F. Korstian and P. W. Stickel.
Divided into two papers and submitted for publication in the Journal of Agricultural Research and as a Department circular.*

"Podsol Formation in Forest Soils", by P. W. Stickel.
Estimated length 3 printed pages plus 5 tables and 5 graphs. Suggested for publication in Ecology. Ready for submission in spring of 1927.

"Observations of Cut-over Pulpwood Lands in the Northeast", by M. Westveld.
Estimated length 10 printed pages plus 2 tables and 2 figures. Suggested for publication in Journal of Forestry. Ready for submission in spring of 1927.

"Reproduction on Cut-over Pulpwood Lands in the Northeast", by M. Westveld.
Estimated length 35 printed pages plus 25 tables and 25 figures. Suggested for publication as a Department bulletin. Ready for submission in spring of 1927.

"Growth on Cut-over Pulpwood Lands in the Northeast", by M. Westveld.
Estimated length 20 printed pages plus 10 tables and 10 figures. Suggested for publication in Journal of Agricultural Research. Ready for submission in winter of 1927-28.

"Influence of Seedbed Conditions on Reproduction of Spruce and Balsam Fir", by M. Westveld.
Estimated length 5 printed pages. Suggested for publication in Journal of Forestry. Ready for submission in summer of 1927.

Finances

Appropriation for Silvicultural Investigations :

In the absence of other information, it is assumed that the Experiment Station's allotment of $27,300 for the present year from the appropriation for Silvical Investigations will be continued without change for the fiscal year 1927-28. No important change in the expenditure of this amount as provided in the current budget is proposed.

Experience indicates more and more clearly the importance of making liberal provision for temporary assistance for both field and office work. On nearly every project field work can be conducted much more effectively if the individual in charge has the help of one or more assistants; and this is even more true of office work. In fact, the apparently inevitable tendency for field work to get ahead of office work makes it essential to provide adequate office assistance if the work is to be kept up to date. Under present conditions the employment of temporary assistants offers the most flexible, economical, and effective means of meeting these needs. More help of this sort than that provided in the budget could be used to advantage if finances permitted.

Attention should, as usual, be called to the fact that the station is in urgent need of additional funds. Satisfactory progress in solving the forest problems of nearly 40,000,000 acres of forest land, lying in five distinct regions, is obviously impossible with an allotment of $27,000 a year. Greater resources are essential to enable the Station to cover adequately the spruce and northern hardwoods region, where nearly all its major projects are now centered, to say nothing of expanding its activities to the other regions.

Cooperative Funds:

Reference has already been made in connection with specific projects to the cooperation received from other agencies. During the past year this amounted to $1,800 for the studies of fire statistics and fire weather, and $2,500 for the white pine weevil study. Contributions of $3,100 for the fire weather study have already been promised for the coming year. Other assistance in the form of contributed time and the loan of equipment has also been received and is anticipated for 1927.

Special attention should be called to the expansion of the Station's activities which has been made possible by these contributions. Without them, far less progress could have been made on either of the fire studies or on the weevil study. The assistance of those who have participated in this way in enlarging the usefulness of the Station is deeply appreciated.